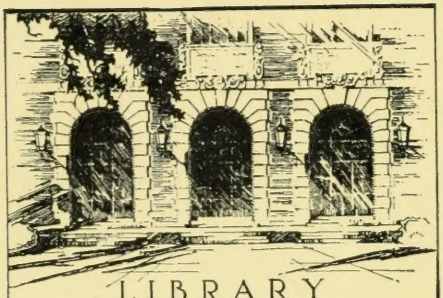

OUSING FOR Wood Ducks

FRANK C. BELLROSE

ILLINOIS NATURAL HISTORY SURVEY CIRCULAR 45

STATE OF ILLINOIS
WILLIAM G. STRATTON, *Governor*
DEPARTMENT OF REGISTRATION AND EDUCATION
VERA M. BINKS, *Director*

HOUSING FOR Wood Ducks

FRANK C. BELLROSE

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The oil painting reproduced on the cover of this publication was painted by Robert H. Cary. The photographs reproduced in the circular were taken by the following persons: Charles L. Scott (frontispiece and pages 1, 4 top, 11 bottom, 13, 14, 17, 20, 24, 25, 32, 36, 37, 39, 42); William E. Clark (pages 4 bottom, 5, 6, 11 top, 22, 23, 29); Robert E. Hesselschwerdt (pages 3, 7); Frank C. Bellrose (page 9 bottom); Harold C. Hanson (page 35); James S. Ayars (pages 9 top, 38). The drawing on page 26 was made by James W. Curfman; that on page 30 by Robert E. Teegardin.

Normally, the wood duck hen leaves her nest twice each day, early in the morning and late in the afternoon, to feed and rest with her mate.

Housing for WOOD DUCKS

FRANK C. BELLROSE

THE wood duck, known to scientists as *Aix sponsa,* is a most unusual bird, differing in many ways from other species of waterfowl. While most ducks nest in meadow grasses and the emergent vegetation of marshes, the woodie usually nests in tree cavities. Unlike other ducks, it spends considerable time perched in trees during the breeding season. Though seeking secluded ponds, lakes, and streams for resting and for rearing its young, it does not hesitate to nest among the dwellings of men.

The drake, with his colorful plumage, elicits the admiration of all who see him. He has a crested head of iridescent greens and purples, a white throat, red eyes, and a red and orange bill; a burgundy breast flecked with white, buff flanks, a white belly,

The wood duck male is one of the most beautiful of North American birds.

and a fuscous back highlighted by iridescent greens, purples, and blues. He is of medium size, weighing about 1.5 pounds; in comparison, the mallard drake weighs about 2.8 pounds and the green-winged teal drake about 0.9 pound.

The hen is slightly smaller and more somber in color. She has a gray-brown head and body and a white throat and eye ring. What she lacks in color she makes up in sound, for she is much more vocal than the male.

Unlike other waterfowl, the wood duck limits its range principally to deciduous forest areas of the eastern half of North America. It is at home in suitable wooded habitats from Florida to New Brunswick, and from southeastern Texas to northwestern Minnesota. A small breeding group inhabits the west coast from central California into southern British Columbia.

The wood duck is the only waterfowl breeding in numbers in Illinois. Here it breeds from the cypress swamps at the southern tip of the state to the tamarack bogs at the northern border, and from the Mississippi River on the west to the Wabash River on the east. In the region of the Illinois River valley near Havana, it reaches its greatest abundance in the state. Few areas in the nation have had as dense breeding populations as this area.

The wood duck has undoubtedly suffered more adversities than have most other ducks. By the early 1900's, the combined effect of habitat destruction and overshooting had so seriously depleted its numbers that conservationists feared the species would be exterminated. The passage of the Migratory Bird Treaty Act of 1918 gave the woodie complete protection from legal shooting. This protection was continued until 1941, when in 15 states a new legal provision permitted one wood duck in the daily bag or in possession of each hunter during the waterfowl hunting season. This legal provision was later extended to most other states.

The protection from hunting afforded the woodie during the 1920's and the 1930's resulted in a general increase in its numbers. But, despite the benefits of protection, in the late 1930's this species was still rare in many places where it was once abundant. Although overshooting was no longer a problem, the destruction of habitat continued to leave its mark on the population.

The situation prompted the Illinois Natural History Survey in 1938 to begin an extensive study of the wood duck, its home life, and its housing requirements. Obviously, with much of its original habitat destroyed by man in his taming of the wilderness,

the species would never again be so numerous as formerly. But help with its housing problems seemed to offer a possibility for increasing or at least maintaining its numbers.

Home Life

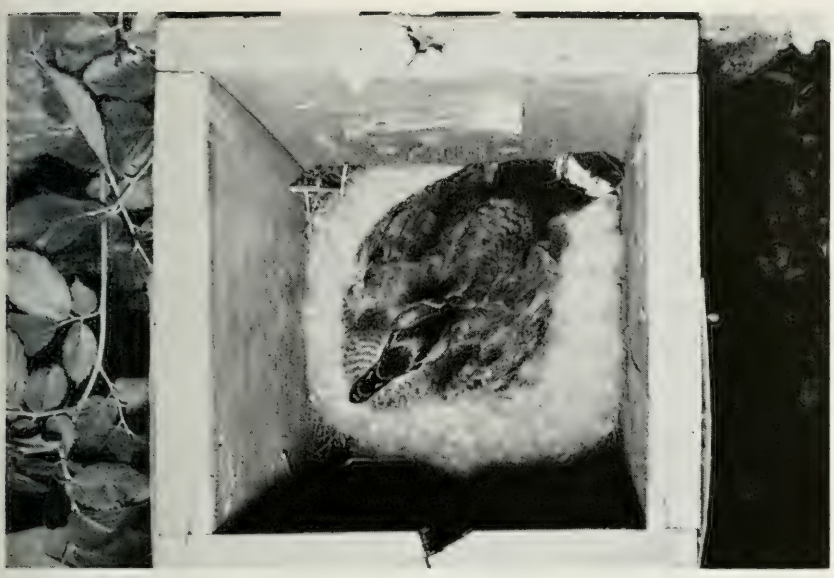
In Illinois, wood ducks begin to nest soon after they return as mated pairs in late winter or early spring from the swamps of Arkansas, Louisiana, Mississippi, or east Texas, where they have spent the winter. In southern Illinois, the nesting season begins in mid-March. In central Illinois, it does not begin until late March. Here the hens continue to nest or renest until late June. Our study shows two peaks of nesting in central Illinois, the first about mid-April and the second early in May.

In beginning their search for nest sites, one to several mated pairs fly from their rest area on a pond or lake to a nearby

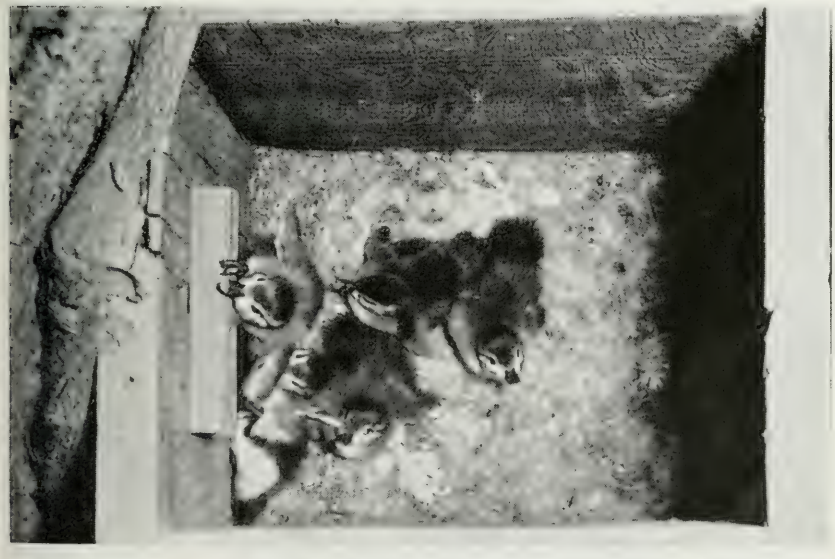
A wood duck hen inspects the local scene for possible danger before calling her recently hatched young from the nest box.

Before departing from her nest to feed, the wood duck hen covers her eggs with a blanket of down plucked from her breast.

When the wood duck hen is incubating, the down forms a fluffy ring around the eggs. The average clutch contains 10 to 12 eggs, but clutches of 6 to 41 eggs have been found in wood duck nests in Illinois.



The wood duck hen does all the incubating, which generally takes about 30 days. The hen shown in this picture has been marked for individual observation by a yellow band painted across her tail.



After the eggs hatch, the hen broods the ducklings in the nest for about 24 hours. Perched in the exit, as shown on page 3, she assures herself that an exodus can be made safely. Then from the ground or a nearby limb, she calls to the young. In response to her call, the ducklings jump and cling to the sides of the cavity, and then "hitch-up" the sides to the exit.

wooded area. Nest hunting takes place usually early in the morning, occasionally late in the afternoon, or, in cloudy weather, during midday. The hen of each pair leads the way as she and her mate dodge among tree trunks and branches in their search for a suitable nest site. Occasionally, she utters a shrill, plaintive *wee-e-e-e-e-k, wee-e-e-e-k!* Alighting on some horizontal limb of a tree, she cranes her neck about, looking for a cavity. When she spots one, she flies to the entrance and gingerly looks in, usually spending considerable time in inspection before entering. Rarely does the drake inspect a nest site; usually, he waits perched on a nearby limb, from which he can warn his mate of approaching danger. The hen may inspect several cavities before selecting one for a nest site.

Generally, the first indication to an observer that a nest is being made is a cup-shaped depression in powdery, decaying wood, leaves, or other loose material in the bottom of the tree cavity or nest box. Egg laying occurs, for the most part, early in the morning at the rate of one egg each day. The drake accompanies his mate to the nest site, and, while she spends from

After reaching the exit, the young wood duck launches itself into space. Usually the ground or water is 10 to 25 feet below the exit.

The duckling flaps its small wings as it falls toward the ground or water.

5 minutes to an hour in the nest, he either waits on a nearby limb or resorts to an adjacent water area. Each time the hen prepares to leave the nest, unless she is frightened, she covers the eggs with the loose material the cavity contains. At about the time she lays the seventh egg, she plucks a small amount of down from her breast and adds it to the nest. She continues to add down throughout the remainder of the laying period.

In a nest in which only one hen lays, the clutch size may vary from 6 to 19 eggs; the average clutch contains 10 to 12 eggs. When more than one hen lays in the same nest, the clutch is usually larger, the size depending generally upon the number of hens laying. Such a nest is known as a dump nest. In one unusually large dump nest, 41 eggs were found.

The eggs are a dull white, ovate in shape, and they measure about 2.0 inches in length by 1.5 inches in width; they are similar in general appearance to the egg of a domestic hen.

Normally, the wood duck hen begins incubating her clutch the day after completing it. She leaves her nest usually twice a day, early in the morning and late in the afternoon, to feed and rest for an hour or so with her mate. During all but the last few days of incubation, the drake accompanies her back to the

nest site. The length of time before ducklings hatch varies from 28 to 37 days; the normal incubation period is 30 days, longer than is required by most species of wild ducks. The normal incubation period for the mallard is 22 to 24 days.

In most cases, the ducklings leave the nest between 8 and 11 o'clock in the morning of the day after they have hatched. Many tales have been told about the way in which the hen woodie is believed to carry her young in her bill, on her back, or under one of her wings to the ground or water, but, in dozens of observations we have made of the departure of the young, we have never seen any such episode. In each case we have observed, the young have made the trip from the nest to the ground, or water, without any physical contact with the hen. When the hen, after inspecting nearby territory, has become convinced that the exodus can be made in safety, she calls the ducklings from the ground or from a limb near the nest. The call, a subdued, high-pitched *pe-e-e* repeated in quick succession half a dozen or more times, apparently acts as a release to the young, which respond with a continuous series of peeps and commence to climb the inside wall of the nest cavity, much as a woodpecker climbs the trunk of a tree. The first duckling at the entrance pauses for a moment before launching itself into space. With webbed feet outspread and tiny wings beating, the duckling jumps without regard for the distance to the ground. One after another, or sometimes two at a time, the other ducklings follow. Occasionally, one or more weak ducklings fail to mount the inside wall and die of exhaustion in the nest cavity.

The hen collects her young, and, if on land, commences to lead them to the nearest suitable body of water. Some of the ducklings may be lost on the way.

Young wood ducks require about 2 months to reach the flight stage. The hen usually remains with them throughout this period. The drake, having left his mate shortly before the eggs hatch, joins others of his sex on secluded woodland ponds or in dense swamps, where they molt.

Nest Predation

The nests of wood ducks are preyed upon by a variety of animals. The eggs may be devoured by raccoons, fox squirrels, opossums, or bull snakes. The shells may be punctured by red-headed woodpeckers, flickers, or starlings. Nests are usually

The nesting wood duck has many enemies, the most important of which is the raccoon. This mammal enjoys eating not only the eggs but the hen herself. The raccoon in this picture is looking out of a slab nest box she used as a den.

The fox squirrel is the second most important predator on wood duck nests in Illinois. Field observations showed that this agile, arboreal mammal is able to enter all natural cavities used by wood ducks and also to circumvent most of the protective metal devices placed on nest boxes. The nest box pictured on page 24, like the one shown here, was an attempt at a squirrel-proof box. Boxes pictured on pages 25 and 29 proved to be squirrelproof.

deserted when one or more egg shells have been punctured. The incubating hen, confined in a cavity, may become the *pièce de résistance* for a hungry raccoon, an opossum, or a mink. Although the ducklings are in the nest cavity only about 24 hours, a surprisingly large number of broods are found and eaten by bull snakes during that short interval of time. In most years of our study, less than half of the wood duck nests we observed were successful, tables 1–3, pages 45 and 46; nest destruction was alarmingly high from 1942 through 1944.

Although fox squirrels, we learned, destroyed more wood duck nests than did raccoons, table 4, page 47, raccoons ranked as the No. 1 predators. They destroyed a larger proportion of nests in an advanced stage of incubation, and, in addition, killed one incubating hen for about every three nests they raided.

The behavior of incubating wood duck hens in the study areas was influenced by fear of raccoons. In the bottomlands, where raccoons abounded, hens invariably left their nests at the slightest disturbance. In the uplands, where raccoons were scarce from 1939 through 1942, incubating birds were more persistent in remaining on their nests. There we often had to lift them off their nests in order to count the eggs.

In 1943, raccoons were driven to the uplands of the Illinois River valley by the highest flood on record. Wood ducks there, previously unmolested by raccoons, soon began to leave nests at the slightest disturbance.

As shown by fur takers' reports, raccoons greatly increased in numbers in Illinois during the 1939–1949 period. From a calculated annual catch of 26,500 in 1939–40 the number rose to 87,000 in the 1948–49 season.

The abnormally high raccoon population had a marked effect on wood duck populations. As a result of high nest losses in raccoon-inhabited woods, the number of wood ducks nesting in such places declined, whereas the number nesting in towns and cities along the Illinois River increased. For example, in Havana, a city of approximately 4,400 persons in 1950, there were not more than 2 nesting pairs each year during the early 1940's, but by the early 1950's there were 10 to 20.

The ducks partially overcame high nest losses by nesting again and again either until they were successful or their opportunities were terminated by the end of the breeding period. By observing banded hens, we found that about 13 days after losing a clutch a hen commenced to lay again. When a nest was

The bull snake is a skillful tree climber and appears to search trees systematically for bird nests. In Illinois, the bull snake accounted for 10 per cent of the losses attributed to predators in the period 1939–1945.

Although the opossum is abundant in central Illinois, where most of the wood duck studies reported here were made, it was responsible for only 1.8 per cent of the wood duck nest losses attributed to predators.

destroyed, the hen did not renest in the same place. Usually she chose a new nest site within one-half mile of the old one, but, in one instance, a hen woodie moved 4.8 miles to renest. We found, further, that there was a definite homing of breeding hens to the nesting area used in previous years. Among the numerous records obtained, a remarkable example was the return in 1951 of four out of the seven hens banded on their nests in an area in which they had nested successfully the year before.

The relocation of nests by renesting wood ducks and the homing to a successful nesting area are mechanisms that apparently aid the wood duck in combating nest depredations. In shifting the nest site following the loss of her eggs, the wood duck hen increases her chances of finding a safe site. In returning to the area where previously successful, she probably increases her chances of nest success over that of random nesting.

We found that where nest success approached, or was greater than, 50 per cent, the number of breeding wood ducks in a given wood lot increased over a period of years. Where nest success was low, a few ducks, or none, nested in the subsequent year or years.

Breeding Habitat

The breeding habitat of the wood duck has two principal requirements: (1) an area for resting and feeding, and for the rearing of young, and (2) a nest site. The wood duck seeks concealment of partially inundated woody cover for resting and for feeding during the day, and for the rearing of its young. Swamps and wooded streams, ponds, and lakes, the shores of which are clothed with partially flooded or overhanging willow, buttonbush, swamp privet, swamp rose, dogwood, or other "brush," meet one phase of the wood duck's living needs. This duck frequently uses the cover provided by the limbs of trees that have toppled into shallow water.

The nest site, the second need, is usually supplied by a cavity in a living tree within one-half mile of a suitable water area. After measuring more than 30 natural cavities used by nesting wood ducks, we found that the average diameter for such cavities was 9 inches and the average depth about 29 inches. Few trees now standing in Illinois have cavities large enough to provide housing for woodies. Unfortunately, most mature timber, in which cavities might be abundant, has been cut and replaced by second growth. The high demand for wood pre-

In addition to suitable nest sites, the wood duck requires wooded ponds, sloughs, or streams for resting and feeding. The area pictured here was favored by many wood ducks. The partially inundated clump of swamp rose, in the background, provided good cover; the logs were favorite loafing spots.

Where trees have fallen into shallow water, the tops furnish cover for wood ducks. In a pond or lake that lacks suitable cover, shore-line trees can be felled to provide cover and resting areas for the ducks.

The day-old duckling shown here is in a natural cavity of a tree in a farmyard near Topeka, Illinois. The cavity has been used by nesting wood ducks for a number of years. Nature requires about half a century to produce a natural cavity suitable for a wood duck nest. A man handy with tools can build, in a few hours, a nest box similar to those shown on page 22.

cludes any possibility that much of the second growth will reach the cavity-forming stage.

The drainage of river bottomlands and other swamps for agriculture has eliminated many resting and feeding grounds and reduced the number of nest sites. In many parts of the eastern half of the United States, and especially in the Mississippi River basin, drainage enterprises have eliminated tremendous amounts of wood duck habitat. Almost half of the 400,000-acre flood plain of the Illinois River valley has been leveed and drained. In the North Arkansas Delta, extending from Cape Girardeau, Missouri, to Helena, Arkansas, about 2,700,000 acres were in drainage districts in 1933 (Eldredge 1938). Most of this area was once swampland. Across the Mississippi River, and to the south, about half of the area of the vast Yazoo Delta bottomlands had been incorporated into drainage districts by 1930 (Stover 1942).

The damming of rivers for navigation, flood control, power, or other purposes in recent years has eliminated tens of thousands of acres of wooded bottomland areas attractive to wood ducks. Many of the vast, recently created bodies of impounded water have bare shore lines and fluctuating water levels, and they lack the oxbow sloughs and other quiet overflow waters of the wooded streams that were dammed to create them. Few of them have as great value for woodies as had the original wooded streams.

Fortunately, many persons are not oblivious to the welfare of the wood duck. Some find an esthetic satisfaction in watching and studying this bird of brilliant plumage and peculiar habits. Others find a sporting interest in this duck, which, although not so highly esteemed a game bird as the mallard, is one of the most delectable. In many areas, the wood duck forms a fairly important part of the hunter's bag. For instance, in the Mississippi River valley from Wabasha, Minnesota, to Alton, Illinois, wood ducks made up 14.0 per cent of all ducks bagged in 1946, 12.0 per cent in 1947, 7.3 per cent in 1948, 3.3 per cent in 1949, and 5.0 per cent in 1950 (Green 1951).

Not being averse to nesting near human habitation, this duck often comes in close contact with man. By erecting boxes suitable for nests, a number of people have succeeded in inducing wood ducks to nest near their homes. For example, at Chillicothe, Illinois, Dr. Frank Green has had more than a dozen pairs nesting about his home each spring for several years. On his premises overlooking the Mississippi River at Burlington, Iowa, Frederic Leopold (1951) has annually had from 3 to 12 nesting pairs. Although living within the city limits of Minneapolis, Minnesota, Dr. Walter Breckenridge has had wood ducks nesting in boxes placed close to his residence, which is adjacent to the Mississippi River.

Those persons having an esthetic or sporting interest in the wood duck can do much to aid the species. Because nest sites can be provided by suitable boxes, sportsmen, bird lovers, and conservation agencies can help to supply one of the two important requisites of the wood duck's breeding habitat.

Advantages of Nest Boxes

Our surveys of natural cavities suitable for wood ducks in potential breeding areas near Havana revealed only one cavity per 13 acres in bottomland timber and about one cavity per 5

acres in upland wood lots. When quality nest sites were scarce, greater use was made of poor or unsuitable sites. At such times, more hens laid their eggs in dump nests. After board boxes were erected in an area, only about half of the natural cavities deemed suitable for these birds were occupied.

Man-made boxes may provide potentially safer nest sites for wood ducks than natural cavities for the following reasons: (1) They are more apt to be weather-proof; (2) they can be more favorably located; (3) they can be made proof against most predators.

Where natural cavities of good quality were insufficient in number, wood ducks used those in the broken tops of trees, which were exposed to rain, or those poorly drained and likely to contain water after a heavy downpour. When nests became very wet, they were deserted.

Generally, the greater the distance a wood duck nests from water, the greater is the hazard faced by the young during the journey from the nest to the water area. Properly placed boxes can reduce the loss of young by providing nest sites close to water areas. A scarcity of cavities may force wood ducks to use nest sites long distances from water; we found several nests in tree cavities more than a mile from the nearest water area.

The loss of young woodies on overland treks may be high. At Burlington, Iowa, Leopold (1951) noted a loss of 61 ducklings from 189 that he observed starting the journey from nest boxes to the Mississippi River, at the bottom of a steep bluff and about a city block away.

Only a few tree cavities we checked had entrances sufficiently small to exclude raccoons, and none that would exclude fox squirrels or bull snakes. In this respect, our early models of nest boxes were no better than good quality natural cavities, for nest success was similar in cavities, table 1, and board boxes, table 3, during 1939 and 1940. However, we were able to design boxes that greatly reduced predation and thereby provided nest sites that proved to be much safer than natural cavities.

Evolution in Nest Box Design

During our 17 years of investigating wood ducks, we directed much effort toward developing and testing new types of nest boxes. Our aims were not only to reduce nest predation, but to reduce the cost of constructing nest boxes and to increase

their durability and the ease with which they can be built, erected, and maintained. Several types of boxes and many types of entrance holes were made and tested during this period. A review of our experiments in nest box construction offers an excellent means of understanding the characteristics of suitable boxes, and may suggest innovations that can be made in successful designs to insure the best use of available materials and labor.

Many bark-covered, slab nest boxes for wood ducks, like the box shown here, were erected in 1936 on the Chautauqua National Wildlife Refuge by the United States Bureau of Biological Survey (Fish and Wildlife Service).

The first wood duck nest boxes to be erected on a large scale in Illinois were made from bark-covered slabs. In 1936, several hundred of these boxes were designed and placed on the Chautauqua National Wildlife Refuge, near Havana, by the United States Bureau of Biological Survey, now the United States Fish and Wildlife Service.

The slab boxes varied somewhat in size, but the inside dimensions averaged 9 by 9 by 24 inches, with the lowest point of the entrance 10 to 16 inches above the bottom of the box. The entrances averaged about 5 inches in diameter. The boxes were placed, usually in tree crotches, about 17 feet from the ground.

In 4 years of inspecting slab nest boxes, we found that slightly less than 12 per cent of them, table 2, were occupied by wood ducks. This low rate of occupancy was the result of several factors: A large proportion of the boxes had cracks near the bottom, which made them unacceptable. Many of the boxes were too shallow. More than half of them were in small trees in bottomlands where wood ducks did not usually seek nest sites. Many were only a few yards from other boxes.

Loss of nests was much greater in the slab boxes, table 2, than in the natural cavities, table 1. The large entrances readily admitted raccoons, which were attracted by the boxes. Entrances rubbed oily and marked by claws and hair indicated that raccoons frequently and systematically visited every box in their territory.

Other disadvantages of the slab boxes were their heavy weight and short life. It was often necessary to use a block and tackle to hoist these boxes into trees. Five years after they had been placed on the Chautauqua National Wildlife Refuge, two-thirds of them had fallen apart.

That the slab boxes were of little value for wood ducks was demonstrated by the low percentage of boxes occupied and the high rate of nest loss, which resulted in a very low production of young.

The types of boxes we designed and tested in our endeavor to increase wood duck nesting success at low cost were, in order, (1) a type made from rough-cut lumber and having a circular opening; (2) a type similar to the first but having a "raccoon-proof" entrance; (3) a type made "squirrelproof" by the addition of sheet metal; and (4) a type made entirely from sheet metal.

In order to prevent others from repeating our mistakes and to stimulate improvements in wood duck nest boxes, we

present here a brief history of the experiments we tried and a summary of the results we obtained.

Box of Rough-Cut Lumber

The first of our wood duck nest boxes of rough-cut lumber was designed and built after Arthur S. Hawkins and the writer, then both employed by the Illinois Natural History Survey, had inspected the slab boxes at the Chautauqua National Wildlife Refuge in 1938 and decided that a more practical nest box could be made. Dimensions of the board box were based upon information gained in measuring 28 natural cavities occupied by wood ducks in 1938. One-inch, rough-cut cypress was selected because of its durability and working qualities. The finished box was about 23 inches deep and measured 10 inches square inside, and it had a 4-inch, circular entrance hole, the center of which was 18 inches from the bottom of the box. The lid protruded a few inches in front. Because the lid was removable for inspection, it was held in place by a block of wood on the underside and hooks and eyes on the outside.

Early in 1939, 450 board boxes of this type were placed in units of 10 to 70 at various places in Illinois, but largely in the Illinois River valley. An additional 250 were erected in 1940. During the winter of 1941–42 the United States Fish and Wildlife Service placed 400 board boxes of similar design on the Chautauqua National Wildlife Refuge.

These boxes were immediately accepted for nest sites by large numbers of wood ducks, table 3. The use of the boxes for nesting gradually increased each year from 1939 through 1942, when unusually severe raccoon predation developed. As a result of extensive nest destruction in 1942, use of the boxes decreased in the succeeding year. The greatest flood on record for the area hit the Illinois River valley in May of 1943, inundating and destroying the nests in most bottomland boxes. Following this further nest destruction, use of wood duck boxes declined in 1944.

The rate of use for these board boxes for the years 1939–1945 was about the same as for suitable natural cavities—about four times the rate for slab boxes. In some of the units, almost every box was occupied during the course of the season, and in numerous instances a box was used twice in the same year.

The value of these board boxes for wood ducks varied from place to place. From the start, some units of boxes had a high

rate of use and a high rate of nest success; other units had a low rate of use and a low rate of nest success. Some units showed an increased use with the passing of years, until predation reduced nest success to a low point, when use of the boxes also declined. In each of these units, the use of boxes in any one year

Rough-cut lumber was used for the wood duck nest box developed by the Natural History Survey in 1939. The box shown here was provided with a wooden "raccoonproof" entrance mask, which a raccoon chewed larger but through which he was still unable to force his body.

was determined largely by nest success in the unit the previous year.

Whether these board boxes provided nestages that were safer than natural cavities was dependent largely on location. Boxes located in the areas of relatively high human activity were of the greatest value for wood ducks. In areas where raccoons and fox squirrels were numerous, boxes of this type sooner or later were subjected to such heavy predation as to make them of little value for increasing wood duck production.

The cost of board boxes varied greatly with the time and the place in which they were built. The type of lumber used, the source of lumber, and the cost of labor were items that affected the cost. In 1939, the cost of cypress boxes built near Havana amounted to about $1.00 per box; $0.60 for the lumber and $0.40 for labor. In 1952, the cost near Havana was about $5.50 per box; $4.00 for the lumber and $1.50 for labor.

Most cypress boxes erected in 1939 were still in good condition in 1954 and appeared likely to last at least another 5 years. Experience showed that, except where there were catastrophes, such as floods or tornadoes, loss of only about 5 per cent of the boxes occurred each year. Such losses were from trees falling with the box or on the box, splitting of the box wood, or breaking of a lag screw or hanger bolt.

Experience showed also that the boxes required annual inspection and the removal of squirrel nests, bees, and other animal life that some of them contained.

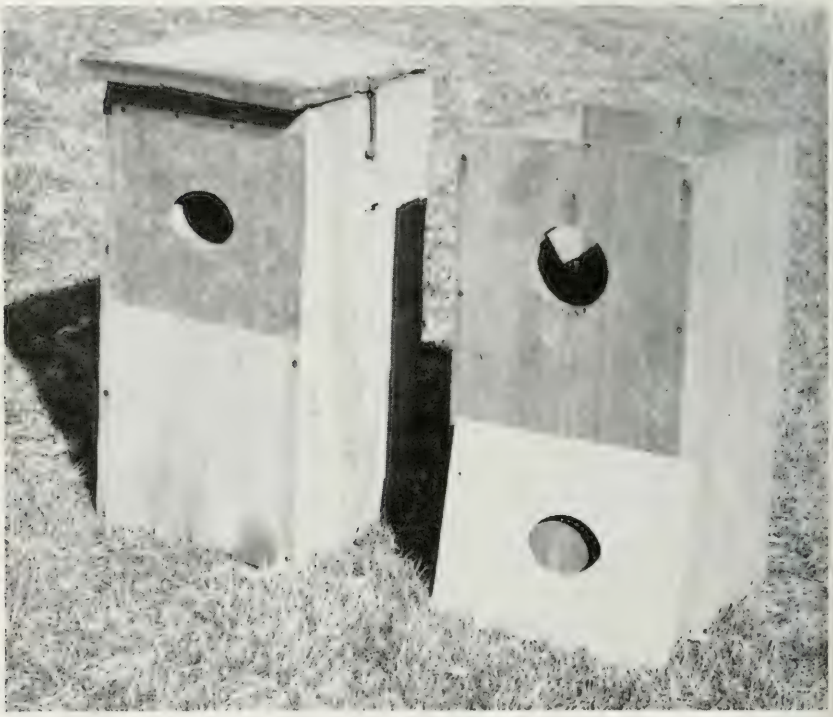
Making Board Boxes Raccoonproof

Early in our study of wood duck nests, we began to seek a way to reduce the losses caused by such predators as raccoons and squirrels, table 4. A few of the successful natural cavities examined had very small entrance openings, which provided a clue to a means of preventing raccoons from reaching wood duck nests. We began in 1941 to experiment with entrances of various sizes and shapes in an effort to find one that would prevent raccoons from reaching nests. Three new entrances were tried that year: (1) a circular hole 3.5 inches in diameter, (2) a diamond-shaped opening measuring 5 inches horizontally by 3 inches vertically, and (3) a rectangular opening 5 inches horizontally by 3 inches vertically. Despite the small sizes of these entrances, raccoons passed through all three types to pilfer wood duck nests.

The following year the diamond-shaped entrance was reduced from a 5-inch to a 4-inch horizontal dimension by a 3-inch vertical one. Tests with captive raccoons demonstrated that it was impossible for an individual of 10 pounds or larger to pass through this aperture. Five out of 10 boxes with this entrance were used by wood ducks in 1942.

We believed that this entrance was satisfactory, and so, in 1944, a wood mask with a diamond-shaped, 4-inch-by-3-inch hole was placed over the 4-inch circular hole on several dozen nest boxes. Observations disclosed that, although some wood ducks were able to pass through this entrance, it excluded many of them. One hen was seen repeatedly trying to enter a box until she finally hung momentarily with her head through the entrance.

The entrance was redesigned to form an elliptical opening, 4 inches wide by 3 inches high, as shown on page 20. In a 6-year period, we found no evidence that wood ducks were unable to enter boxes provided with this entrance. Although numerous



In 1948, a metal mask with a "raccoonproof" opening was developed to prevent raccoons from pilfering the wood duck nest box of rough-cut lumber.

raccoons attempted to enter these boxes, in only one instance was one known to have been successful. In this case, the entrance had been cut too nearly round. In another instance, an incubating hen was killed by a raccoon; this duck, evidently frightened into leaving the nest, was grabbed at the opening of the box. Her decapitated body was found inside. Several hens deserted their nests because of the disturbance created by raccoons attempting to enter the nest boxes.

With these few exceptions, wood duck nest boxes provided with the elliptical, 4-inch-by-3-inch entrance have been effective in preventing nest destruction by raccoons. The cost of one of

A wood duck hen leaving a nest box through a "raccoonproof" opening shows how the aperture conforms to the shape of her body.

these "raccoonproof" entrances is so little more than that of a circular opening that all boxes should be made with this entrance. We found that the easiest way to make this entrance is to bore a 4-inch, circular hole in the box and then to mask it with a 10-inch-square piece of galvanized metal in which a "raccoonproof" opening has been cut, as shown on page 22. It is easier to cut an elliptical aperture in metal than in wood. Also, the metal mask prevents raccoons from enlarging the entrance.

Making Board Boxes Squirrelproof

In 1939–1945, fox squirrels accounted for 51.1 per cent of the destroyed wood duck nests in board boxes, table 4. Destruction of nests by squirrels was especially heavy in black oak wood lots bordering the Illinois River between Pekin and Beardstown.

Although sheet metal flanges of many shapes and sizes were tried in an effort to keep squirrels out of wood duck nest boxes, they were unsuccessful.

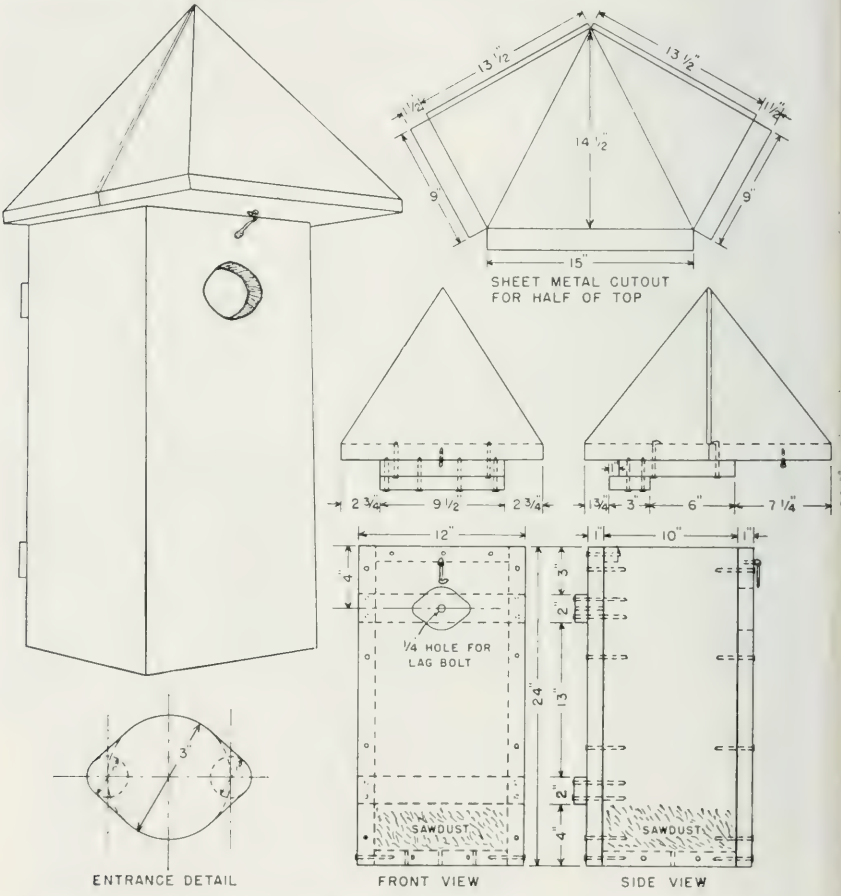
In 1941, we began to study methods of preventing fox squirrels from pilfering the nests. Bands of *Tanglefoot*, a gummy substance used to prevent moth larvae from crawling up trees,

Board nest boxes were made "squirrelproof" by covering the sides and front with a single sheet of metal and adding a pyramidal metal roof.

were placed around tree trunks about 2 feet below and 4 feet above nest boxes. Where bands of *Tanglefoot* were 12 to 14 inches wide and no adjacent tree or branch was sufficiently close for a squirrel to jump to the box or tree trunk between the bands, the nests escaped destruction by squirrels and also by raccoons. Only a small proportion of the trees in any woods, however, met the requirements needed to make the *Tanglefoot* barrier effective.

The *Tanglefoot* barrier was then tried on the box itself, but fox squirrels jumped over it or even went through it to raid the wood duck nests.

Because of the physical limitations in using *Tanglefoot* and the necessity of renewing it each year, an effort was made to find an effective barrier that could be built into the nest box. During the next few years, experiments were attempted with sheet metal flanges of various dimensions arranged both at right angles to the front of the box and at right angles to the side of



This plan for a wood duck nest box of rough-cut lumber has features that are designed to make the box predatorproof. The elliptical opening keeps out raccoons. The metal roof and metal front and sides prevent squirrels from entering to pilfer eggs. Rough-cut cypress makes a durable box. Cheaper lumber can be used for sides and front covered with metal.

the box, as shown on pages 9 and 24. Though flanges of various widths from 6 to 12 inches were used, the squirrels continued to reach the box entrance.

Observations on captive squirrels revealed that their usual mode of access was to cross the top of the box to the top flange, perch momentarily on the edge with all four feet, release their front feet, and swing down toward the opening, arching their bodies as they released the grip of their hind feet. Occasionally, squirrels missed catching the rim of the entrance and fell to the ground. Misses evidently did not deter the animals in nature, for as many wood duck nests were destroyed in boxes provided with metal guards as in boxes without such guards.

Our next approach was to cover the front and sides of a board box with sheet metal, and to affix a pyramidal metal roof. This box proved fairly effective in tests with captive squirrels.

When we tested this box in the field, however, we found that squirrels entered it more frequently than had been indicated by experiments with captive squirrels. Some squirrels were able to maintain their footing sufficiently down the pitched roof to leap for and catch the rim of the entrance. Although squirrel predation on wood duck nests appeared to be reduced in these boxes, numerous nests were pilfered.

The roof was redesigned for the 1950 nesting season. The pitch was increased, and the roof was given a 6-inch overhang in front, 2 inches more than in the previous design; also, the roof was extended an inch on each side. The box with the redesigned pyramidal roof is shown on pages 25 and 26.

As determined from field observations in 1950 and 1951, fox squirrels entered only those boxes located where they could jump from an adjacent branch directly to the entrance. Wood ducks readily accepted this type of nest box; and there appeared to be no significant difference in use between this type and board boxes without metal covering.

The high cost proved to be the principal disadvantage in making a board and metal box almost completely immune from tree-climbing predators. The cost of the sheet metal plus the labor in making the pyramidal roof amounted to $4.00 in 1952. Some saving was achieved by making the surfaces that were sheathed with galvanized metal out of wood other than cypress. With cheaper lumber on the sides, front, and top, the board box in 1952 cost about $4.50, which together with the metal totaled about $8.50.

Galvanized-Pipe Nest Houses

In 1950, we made a different approach in the development of a "predatorproof" wood duck house. At the suggestion of Louis Ellebrecht, then refuge manager of the Chautauqua National Wildlife Refuge, a galvanized, cold-air pipe of 26-gauge metal, 12 inches in diameter and 24 inches in length, was used to form the body of the house, as shown on pages 29 and 30. A "raccoon-proof" entrance was cut with its upper edge about 3½ inches from the upper end of the pipe section. An inverted, galvanized metal cone 15 inches in height was used for the roof; two metal screws were used to attach the roof to the pipe section so that the roof could be removed for inspection. The bottom was formed either by a circular piece of galvanized metal soldered to the lower end of the pipe section, or by a block of wood inserted into this end and secured there by screws.

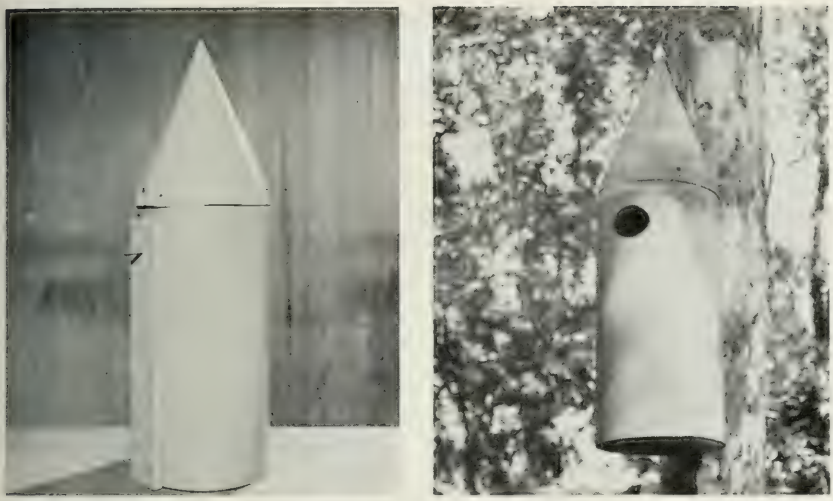
To make the galvanized pipe more rigid, a 1-by-3-inch strip of wood was bolted to the back of the house, as shown on page 29. This strip of wood could be extended above and below the house to facilitate attachment of the house to a tree trunk; usually, however, a one-half-inch hole was bored opposite the entrance for insertion of a lag screw or hanger bolt by which the box was attached to a tree trunk.

The metal pipe was lined with half-inch insulating fiber board in order to provide footing for the young wood ducks climbing from the nest. A circular section of this material was inserted into the conical roof for insulation, but this does not appear to be necessary.

None of the five metal-pipe houses erected in 1950 was used by wood ducks in that year, but that fact is not surprising in view of the low use of other boxes in the area. Moved to a new area in 1951, three of the five were used by wood ducks. These figures represent a higher rate of occupancy than that found for other types of boxes on the area.

Examination of the metal houses used by wood ducks revealed that the claws of the incubating birds had worn the lining of composition board to such an extent that the material probably would need replacement in a few years. A search was therefore made for a more durable lining.

Of the several materials considered, the best appeared to be a tarlike substance used to undercoat automobiles. The undercoating material, use of which was suggested by James D. Mc-



This metal-pipe nest house was designed in 1950. It deters predators; it is relatively inexpensive, light, easily erected, and durable. A wooden brace at the back provides stability when the house is attached to a tree.

Call, Waterfowl Biologist of the Indiana Department of Conservation, was applied to the inside of the metal-pipe houses so that it formed a rough layer, one-sixteenth to one-eighth inch thick. A brush was used to apply the material, which was roughened by daubing to provide ducklings with "toe holds" upon their departure from the house.

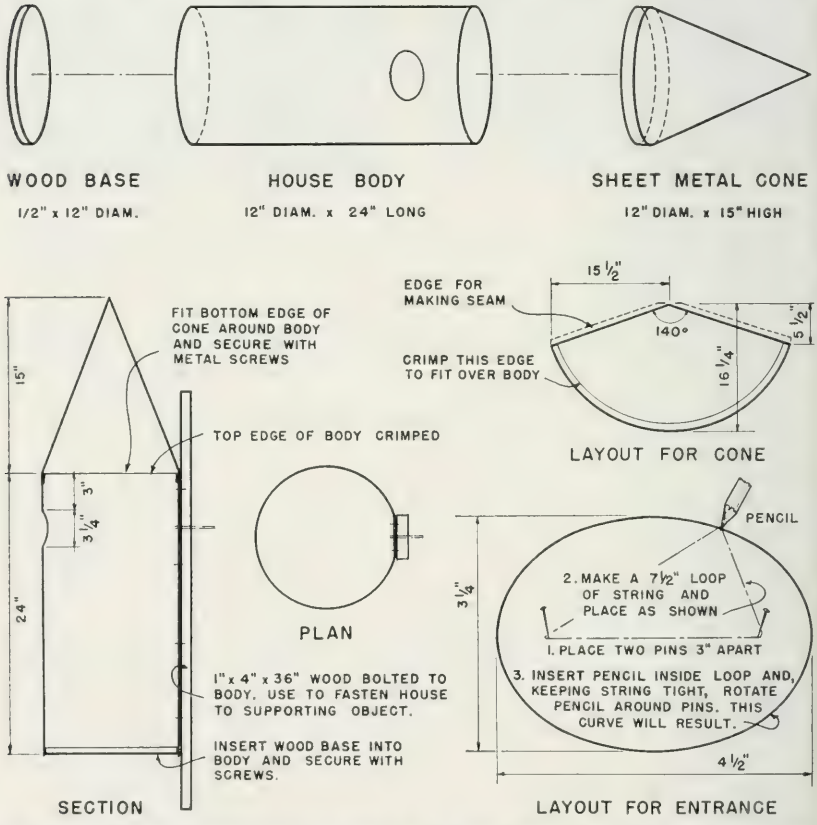
When dry, the undercoating material formed a rough, resilient lining which should last as long as the metal parts. Coating the interior also aided in preventing rust and increasing the rigidity of the metal.

A comparison of the use, by wood ducks, of several types of nest houses suggested that the galvanized-pipe house with the undercoat lining is not as acceptable to the ducks as the one with the fiber board lining, table 5. Field observations indicated that the hen woodie has unusual difficulty in alighting at and pushing her body through the entrance of the undercoat-lined pipe house because of the thin lip of this entrance. Evidently, the entrance of the pipe house with fiber board lining (one-half inch thick) provides better footing for a hen to cling to than does the entrance with the lining of undercoat material (one-eighth inch thick).

In entering a nest house having a small opening, the wood duck hen invariably clings momentarily to the edge of the open-

ing and then "ducks in"; she does not fly directly into the nest house as she usually does into a house with a large opening.

Defects in the linings of galvanized-pipe nest houses—the thinness of the undercoat material, use of which resulted in a thin-lipped entrance, and the impermanence of the fiber board—stimulated search for a better lining. A lining for the inside front of the house was made from vermiculite (a mica material used for building insulation) and undercoat material. The vermiculite was stirred into the undercoat material until a stiff



This plan shows construction details of the latest model galvanized-pipe nest house for wood ducks. Dimensions for the "raccoonproof" entrance, larger than for the entrance of the box of rough-cut lumber, allow for curvature of the pipe. The top of the cylindrical section is crimped enough to permit the roof to fit over it easily. One to three upholstery clips or metal screws hold the roof in place. The back of the house is flattened somewhat and held firmly against the wooden brace by six to eight screws or bolts. The edges of the entrance are smoothed with a file. Linings, not indicated here, are discussed in the text.

doughlike mixture resulted. The mixture was then applied with a trowel to a thickness of about one-half inch and a width of about 6 inches down the inside front of the house from the entrance to the bottom. The remainder of the inside of the house was covered with the undercoat material or, in some instances, left bare.

The vermiculite-undercoat mixture was applied too late for field tests in 1954. However, it appears to provide a durable and adequate footing at the entrance for the wood duck hen to cling to on her way into the box and for newly hatched ducklings to use as a ladder on their way out.

Construction details of the latest model galvanized-pipe nest house are shown on page 30. The house can be attached to a tree by a lag screw or hanger bolt through pipe and wooden brace at the back of the house opposite the entrance, or by two of these screws or bolts through the brace, one above and one below the house.

In 1954, the cost of a metal-pipe house, when made in lots of 50 or more, was about $5.25. The metal plus a tinsmith's labor amounted to $3.75. The addition of a wood support brace at the back and paint to the exterior cost about 50 cents. The mixture of vermiculite and undercoat material down the inside front of the house plus undercoat elsewhere inside the house amounted to about $1.00 when the undercoat was applied with a brush; the cost of commercial spraying of undercoat has varied from 50 cents to $3.50 per house. The metal-pipe house compared favorably in cost with the cypress board box, and it cost about $3.25 less than the board box covered with sheet metal.

As yet there has been no evidence that fox squirrels or raccoons have been able to enter this type of nest house when properly erected. Only rarely have bull snakes succeeded in entering to consume clutches of wood duck eggs. The metal-pipe house is the most nearly "predatorproof" of those described. Its "predatorproof" quality, its light weight, and its durability make it the best nest house we have yet devised for the wood duck.

Nail-Keg Nest Houses

Nail kegs can be easily converted into wood duck nest houses, as shown on page 32, but these houses are less satisfactory, even, than board boxes. Where both types have been present in the same area, the rate of use by woodies has been about twice as

great for the board boxes as for houses that have been made from nail kegs.

The method of converting nail kegs into wood duck nest houses has been included here largely for the benefit of Boy

Wood duck nest houses can be cheaply made from nail kegs. The top, of wood, is hinged to a wooden brace at the back. The wooden brace is 1 by 3 inches, 30 inches in length; the extended ends can be nailed to the tree trunk. Nest houses of this type are less satisfactory than board boxes.

Scout, 4-H, and other youth groups that may desire to make a simple, inexpensive type of house.

Nail kegs are of two sizes: (1) 10 inches in diameter at the ends and 17 inches high (those in which common nails are shipped) ; and (2) 11.5 inches in diameter at the ends and 17 or 18 inches high (those in which galvanized nails are shipped). The opened end of each keg is used as the top, and the entrance is cut as close to the top as possible. Usually the upper wire surrounding the staves can be bent down sufficiently for a "raccoonproof" entrance to be cut between it and the metal ring above.

A strip of wood, 1 by 3 by 30 inches, can be nailed to the back of the keg as a brace. A board top, large enough to allow an inch or more of overhang, can be hinged to the wood brace at the back and fastened with a hook and eye in front. The keg can be easily attached to a tree by nails driven into the wood brace. Advantages of the nail-keg nest house are its low cost, lightness, and ease of attachment. The cost of the roof, wood brace, and paint amounted to about 75 cents at 1952 prices.

Miscellaneous Construction Details

The following suggestions are general in nature and apply to several types of wood duck nest boxes or houses.

Interior.—For the board box, rough-cut lumber is the preferred material, as it enables the ducklings to climb the inside front of the box to the entrance. If rough-cut lumber is not available and it is necessary to use planed lumber, a "stairway" of hardware cloth should be attached to the inside front of the box.

Exterior.—Although cypress is recommended for the board box because of its resistance to weathering, the cost of cypress in many localities is double or triple the cost of fir. Where the price of cypress is excessive, a cheaper lumber can be used, if it is treated with a pentachlorophenol or copper naphthenate wood preservative solution. The cost of treating a box with a preservative is about 25 cents.

We found no difference in the acceptance by wood ducks of painted and unpainted boxes. To increase durability and improve the appearance of both wood and galvanized metal boxes, an outdoor, flat, neutral-color paint should be applied.

Defects.—A box that has one or more knotholes or cracks near the bottom should have these defects covered with galvanized metal to exclude light from the interior. We found that wood ducks avoided using boxes with cracks or holes unless forced to use them by a lack of other sites.

Nest Material.—Boxes must be supplied with a 2- or 3-inch layer of sawdust, wood chips, shavings, or dead leaves to provide a base for the wood duck nest. We found that boxes without sawdust or similar material were not used by wood ducks. The base material is used to cover the eggs during the laying period, and it is formed into a saucer-shaped depression to contain the completed clutch.

The Box to Make

Money, material, labor, transportation, the placement area, and the number of boxes to be made are some of the factors to consider in deciding the type of wood duck box to make and install. What may be feasible for state or federal conservation agencies may not be feasible for a sportsmen's club, nature club, 4-H club, or Boy Scout troop.

Fortuitous circumstances may make a particular material available at very low cost. In southern states, it should be possible to purchase cypress boards directly from small sawmills at much lower prices than through retail outlets.

When labor for building boxes is donated, as by sportsmen, or the labor cost is part of fixed salaries, as for refuge personnel, the best economy may dictate the use of the board nest box, which almost anyone can build. On the other hand, when carpenter costs are involved, the galvanized metal-pipe house may be more economical.

Not only should the metal-pipe house last longer than other types, but its maintenance costs should be lower. Many board boxes are so filled with leaves by fox squirrels that they are useless for wood ducks until cleaned. Whereas the board box generally requires yearly maintenance, the metal-pipe house needs to be visited only once in every 3 to 5 years to reduce the pressure put on it by increased tree growth.

Even when the initial cost of the metal-pipe house is higher than that of the board type, the metal type may still be less expensive, if the cost is prorated over the life of the structure.

The light weight of the metal-pipe and nail-keg houses makes them much easier to transport and put in place than board boxes. When nest boxes must be carried long distances, weight is an important factor.

It is an unnecessary expense to make the "squirrelproof" nest box for areas where squirrels are no problem, unless this type is as economical to build as the board type. In most wood duck habitats, however, squirrels are a potential if not an actual menace to wood duck nests.

Placement of Nest Boxes

In our experiments, the placement of nest boxes proved to be as important as their design and construction. Boxes placed

very low over land or very far from water were little used. Breeding ducks avoided boxes that were attached insecurely or were shielded by a dense canopy of branches.

Distance From Water.—Wood ducks were found to use boxes over water and in other suitable areas as much as a mile or more from water. One unit of boxes on the Mason County State Forest was about 1¼ miles from the nearest water area, and it had a number of nests each year, 1939 through 1944. As previously

Wood duck nest boxes near the right and left margins of this picture are in an ideal upland habitat: a mature black oak wood lot adjacent to an Illinois River bottomland lake, near Bath, Illinois.

mentioned, however, the greater the distance, the greater is likely to be the mortality among the young on their overland trek from nest site to water area. Therefore, it is suggested that nest boxes should be placed not more than a few hundred yards from a water area.

Types of Woods.—In the Illinois River valley, we learned, nest boxes located in upland woods had a higher occupancy rate than those in bottomland woods. Two factors were probably responsible for this difference: (1) Nest cavities, more abundant in upland woods than in bottomland woods, attracted wood ducks.

(2) Raccoons, more numerous in bottomland areas than in upland areas, repelled the ducks.

As discussed earlier, wood ducks tend to return to areas in which they have previously nested successfully. The yearling and the old birds congregate early in the breeding season, and evidently the yearlings follow the adults to nesting areas. They are

The wood duck nest box shown here is in an ideal bottomland habitat: an open area in a dense wood with many mature trees.

prone to seek nest sites in favorable locations, locations that, in the past, have had an abundance of natural cavities or man-made nest boxes and few, if any, raccoons or other predators. The homing pattern showed up in wood lots, where we found more wood ducks seeking nest sites in areas with high nest success than in those with low nest success.

We found that the use of nest boxes newly placed in an area depended at first upon previous nest success in the natural cavities in the area. In areas in which boxes had been used, and in

The rough-cut board nest box shown here is attached about 15 feet above the ground to the trunk of a black oak tree on the edge of a farm wood lot. This wood lot is near the house pictured on page 39. Wood duck nests located near dwellings were molested less by raccoons than those more distant.

which nest success was above 50 per cent, an increasing use was made of nest boxes. As shown in table 3, the use of nest boxes in any one year was dependent largely upon nest success the previous year.

Nest boxes placed in comparatively open stands of mature trees with large, spreading limbs had a higher rate of occupancy than those placed in dense stands of young trees. Woodies evidently prefer to fly to their nests through a relatively open canopy, and to perch on large, horizontal limbs near their nests. The penchant for nest sites in open areas was shown to be great where nest boxes were on dead trees standing in water. Nest boxes placed on dead trees in the Mississippi River near Clinton,

Iowa, had a much higher use rate than those placed on live trees of nearby wooded islands.

Attachment to Trees.—Nest boxes and houses for wood ducks should be mounted in a vertical position 10 to 25 feet above the ground on tree trunks where no branches shield the entrances. Natural cavities that we found being used for nests were 4 to 60 feet above the ground, but most were at heights of about 18 feet. For convenience, most of the wood duck nest boxes used in

The wood duck nest box is rested on the safety belt while it is being attached with a lag screw to a tree.

our study were so placed that the entrances were about 15 feet above the ground. They were easily attached to tree trunks by a crew of two men working together.

Equipment necessary for such a crew includes a 10- or 12-foot ladder, a lineman's safety belt, and a brace equipped with a socket wrench. One man stands on one of the top rungs of the ladder, which he has leaned against a tree trunk, and wraps the free strap of his safety belt around the trunk. After taking a

Wood ducks are not averse to nesting near human beings. This nest box, near Bath, Illinois, was used by woodies almost every year, 1940–1948.

nest box handed up to him by the other man, he rests it on the strap to hold it steady while it is being attached, as shown on page 38. Climbing irons may be more convenient than a ladder if the boxes are to be placed more than 15 feet above the ground.

One method of attachment is to insert a lag screw through a three-eighths-inch hole bored in the back of the box opposite the entrance and turn the screw with the brace until the box is drawn firmly against the tree. The length of the lag screw may vary from 4 to 6 inches, depending upon the type of nest box and the thickness of the bark of the tree.

Another method of attachment is to screw a hanger bolt into the tree trunk, hang the box on the bolt through the hole bored in the back, and draw the box firmly against the tree with a wing nut. Washers should be used between the wing nut and the box, or between the head of the lag screw and the box. With either a lag screw or a hanger bolt, the strain imposed on a box by a growing tree can be readily relieved every few years by a few loosening turns of the screw or the wing nut.

Boxes on Poles in Water.—The Massachusetts Division of Fisheries and Game recently had very favorable results from placing wood duck nest boxes on poles in marshes and shallow-water areas (McLaughlin & Grice 1952). The poles were driven into the bottom mud and the boxes attached to the poles only a few feet above the water. Wood ducks made a greater use of the nest boxes erected over water than they did of boxes erected over land. A benefit gained in placing boxes over water was the elimination of squirrels as important nest predators.

Only relatively stable bodies of water are suitable for the erection of nest boxes on poles; in areas where wave action or ice action is severe, the poles are likely to be pushed over. Farm ponds, beaver ponds, and other small water areas afford ideal places for boxes placed on poles.

Spacing of Boxes.—The social nature of wood ducks results in their nesting close together where possible. We have had the highest rate of occupancy of nest boxes where the boxes were grouped 50 to 100 yards apart, rather than where they were strung out 200 to 300 yards apart.

The denser the population of wood ducks, the larger is the number of boxes needed per unit of area. In the Illinois River valley, the number of boxes we erected ranged from 0.3 to 4 per acre; the average was about 2. In several units of boxes grouped at the rate of 2 to 4 per acre, every box was occupied.

In an area where wood duck populations are sparse, it is advisable to put up only a small number of boxes and to wait until about 40 per cent of them are occupied before adding other boxes as the nesting population increases.

Under favorable nesting conditions, a local breeding population of wood ducks will increase for a period of years until a more or less stable condition is reached. When the breeding population of ducks becomes dense, miscellaneous animals, such as red-headed woodpeckers, flickers, or starlings, not normally addicted to destroying wood duck nests, may become important predators. Fewer eggs will hatch per hen as more hens lay in community or "dump" nests, for under such conditions the hatchability of the eggs is lower, and often entire nests go unincubated.

Establishment of Wood Ducks in New Areas

There is a desire on the part of many people to put up nest boxes for wood ducks in the hope that these birds will be attracted to their property. In localities within the population range of the species, absence of wood ducks may be due to (1) a habitat (either nest sites or resting and feeding area, or both) lacking in suitability; (2) predation at some previous time so severe that losses in the adult population exceeded the replacement until, over a period of years, the breeding nucleus dwindled away; (3) a suitable habitat so newly created that the birds have not as yet infiltrated.

We conducted several experiments to determine if new colonies of wood ducks could be established by strengthening the nesting habitat through erection of nest boxes and by releasing pen-reared young for potential breeders.

The first experiment was at the Bright Land Farm, near Barrington, Illinois, where 50 pen-reared young were released in midsummer of 1941 and 31 in midsummer of 1942. Two small, artificial lakes had been previously constructed on the property; one of them was marshy and shallow, the other devoid of vegetation and fairly deep. Neither lake was especially suitable for wood ducks because of the paucity of overhanging or partially inundated woody cover. In the oak woods near the lakes, 40 wood duck boxes were erected.

In 1941, a pair of wood ducks native to the area nested in one of the boxes. The following year, there were four incubating hens using nest boxes; three of these were from the 50 juveniles

released the summer before. In 1943, there were at least eight different breeding pairs. Three hens were captured on their nests; all were pen-reared birds.

In subsequent years, the number of breeding wood ducks declined at the Bright Land Farm. C. A. Beckhart, the game manager, reports that two or three pairs have nested there each year.

The young wood duck can swim when less than 24 hours old. It remains with its mother until it has learned to fly at the age of 8 to 10 weeks. Nest boxes should be placed within a few hundred yards of a water area.

In 1951, three broods were observed; in 1953, two broods. Thus, the habitat did not maintain the artificial high resulting from the release of pen-reared birds. One wild wood duck had nested at the farm in 1941, and the release of pen-reared birds did little toward permanently augmenting the number of breeders there.

A release of pen-reared wood ducks was made at the Jasper-Pulaski State Game Preserve near Medaryville, Indiana, in cooperation with the Indiana Department of Conservation. Ninety-five young, raised until about 10 weeks of age at Havana, Illinois, were banded and released at the game preserve in July, 1944.

In 1945, four banded hens from the release were found in nest boxes, and, in addition, one of the released hens was cap-

tured during the spring in a duck-banding trap. Therefore, at least five hens, perhaps more, returned to nest in the area where they had been released the year before.

Some of the wood ducks that nested at the Jasper-Pulaski State Game Preserve in 1945 were there as a result of the release of birds and the erection of nest boxes, but, because a few wood ducks had bred there before, it is difficult to determine the part the release played in the breeding population of subsequent years.

Up to 1944, wood ducks had not been known to breed in the Lake Wingra area, near Madison, Wisconsin, for more than 50 years. In the entire Madison region, none had been known to nest for at least a decade.

Could the wood duck be re-established in the Madison area as a breeding bird? To find the answer to this question, the Illinois Natural History Survey and the Wildlife Department of the University of Wisconsin released 97 young, about 7 weeks old, at Lake Wingra in August, 1944. The following year, two banded hens, presumably from the release, were observed by Dr. Robert McCabe of the University of Wisconsin at their nests in natural cavities near Lake Wingra, and during the summer three broods were seen that were believed not to be from either nest. During the spring of 1946, many wood ducks were seen about Lake Wingra, and one of the nest sites that had been used previously was occupied until destroyed by wind. Although no broods were observed on Lake Wingra, two broods were seen on the University Bay of Lake Mendota, about 2½ miles from the original release site. From 1946 to the present time, one to five broods of wood ducks have been seen each year in the Lake Wingra area. Because wood duck broods are difficult to find, probably many more have been raised there. It is safe to conclude that the introduction of wood ducks in 1944 was successful in re-establishing the species as a breeding bird in the Madison area.

The Place of Nest Boxes in Wood Duck Management

The woodie came back, part way at least, during the 1920's and 1930's because it was protected from shooting, and probably also because raccoon populations were low. Whether this duck will return to the ranks of endangered species will, of course, depend upon the balance between productivity and mortality.

With increased lumbering of bottomland hardwoods, with increased drainage of southern swamps, with a high raccoon

population in the Mississippi River basin (Sanderson 1951*a*, 1951*b*, and Illinois data), it is no wonder that the production of wood ducks in many sections of the United States has been low in recent years and is likely to be low for years to come. Replies to a questionnaire sent in 1950 to wildlife technicians and ornithologists across the country indicated that, concurrent with the build-up in raccoon populations, a decline in wood ducks was noted in many places of the Mississippi River basin but that in some parts of the United States no general decrease in wood duck numbers occurred; perhaps in areas in which no decrease occurred raccoons were no greater menace than previously.

To make a significant contribution to the production of young wood ducks in the Mississippi Flyway, perhaps 40,000 nest boxes would be required. Each state in the flyway would need to contribute 1,000 to 5,000 nest boxes, the number depending upon quantity and quality of breeding habitats. The cost of such a program would be small compared to the cost of present land acquisition projects and upland habitat restoration programs.

Although nest sites are only one requirement in the management of wood ducks, the scarcity of natural cavities is so great that nest boxes represent an important and tangible means by which conservation-minded individuals or groups can make significant contributions to the welfare of these beautiful birds.

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Table 1.—The number and per cent of suitable natural cavities used as nest sites by wood ducks, and the number and per cent of occupied sites that were successful, all near Havana, Illinois, 1939 and 1940. Most of these cavities were in black oak woods.

Year	Number of Suitable Cavities	Number of Suitable Cavities Occupied	Per Cent of Suitable Cavities Occupied	Number of Occupied Cavities With Successful Nests	Per Cent of Occupied Cavities With Successful Nests
1939	85	40	47.1	18	45.0
1940	67	37	55.2	20	54.1
Total	*152*	*77*		*38*	
Average			**50.7**		**49.4**

Table 2.—The number and per cent of bark-covered slab boxes used as nest sites by wood ducks, and the number and per cent of occupied sites that were successful, all near Havana, Illinois, 1939–1941.

Year	Number of Boxes	Number of Boxes Occupied	Per Cent of Boxes Occupied	Number of Occupied Boxes With Successful Nests	Per Cent of Occupied Boxes With Successful Nests
1938	205	28	13.7	7	25.0
1939	399	45	11.3	8	17.8
1940	349	44	12.6	10	22.7
1941	225	21	9.3	17	81.0
Total	*1,178*	*138*		*42*	
Average			**11.7**		**30.4**

b' 3.--The number and per cent of board nest boxes used as nest sites by wood ducks, and the number and per of occupied sites that were successful, all in the Illinois River valley, 1939–1945.

Year	Number of Boxes Examined	Number of Boxes Occupied	Per Cent of Boxes Occupied	Number of Occupied Boxes With Successful Nests	Per Cent of Occupied Boxes With Successful Nests
1939	349	181	51.9	83	45.9
1940	401	233	58.1	134	57.5
1941	376	243	64.6	120	49.4
1942	723	470	65.0	143	30.4
1943	559	279	49.9	44	15.8
1944	334	106	31.7	22	20.8
1945	476	67	14.1	28	41.8
Total	*3,218*	*1,579*		*574*	
Average			**49.1**		**36.4**

Table 4.—Number of wood duck nests destroyed by the fox squirrel, raccoon, bull snake, and opossum, and the per cent of destroyed nests attributed to each animal. All nests were in board boxes located in the Illinois River valley, 1939–1945.

	Fox Squirrel		Raccoon		Bull Snake		Opossum		Total	
Year	Number	Per Cent	Number	Per Cent	Number	Per Cent	Number	Per Cent	Number	Per Cent
1939	34	40.0	39	45.9	11	12.9	1	1.2	85	100.0
1940	43	60.6	14	19.7	14	19.7	0	0.0	71	100.0
1941	83	76.8	18	16.7	7	6.5	0	0.0	108	100.0
1942	103	38.7	118	44.4	32	12.0	13	4.9	266	100.0
1943	97	49.2	93	47.2	7	3.6	0	0.0	197	100.0
1944	38	63.3	11	18.3	10	16.7	1	1.7	60	100.0
1945	21	63.7	11	33.3	1	3.0	0	0.0	33	100.0
Total	*419*		*304*		*82*		*15*		*820*	
Average		**51.1**		**37.1**		**10.0**		**1.8**		**100.0**

Table 5.—The number and utilization of several types of wood duck houses in a unit along Quiver Creek near Havana, Illinois, 1952–1954.

Type of House	Number of House-Years*	Number of Nest-Years†	Per Cent of Use
Wood, flat top, "raccoonproof" entrance	20	3	15.0
Metal-covered wood, pyramidal top, "raccoonproof" entrance	46	9	19.6
Galvanized metal pipe, insulating fiber-board lining, "raccoonproof" entrance	10	3	30.0
Galvanized metal pipe, undercoat lining, "raccoonproof" entrance	24	3	12.5

* A house-year is one house available for a nesting season.
† A nest-year is one nest that occupies a house for all or part of a nesting season.

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